REMOTE RAMAN IMAGER FOR FAST DETECTION OF MIXED MINERAL LAYERS AND BIOMATERIALS. T. E. Acosta-Maeda¹, A. K. Misra¹, G. Berlanga¹, D. Muchow¹, S. K. Sharma¹, M. N. Abedin², and A. T. Bradley², ¹ Hawai‘i Institute of Geophysics and Planetology, Univ. of Hawai‘i at Mānoa, 1680 East-West Rd, Honolulu, HI, 96822 (tayro@hawaii.edu) ²NASA Langley Research Center, Hampton, VA, 23681, USA

Introduction: Raman spectroscopy has the power to univocally identify a large variety of chemicals, from mineral to organics [1,2]. The capability of acquiring time resolved Raman and fluorescence measurements allows for daytime fast Raman measurements and for the detection of bio-fluorescence [3] and provides a highly sensitive detection of minute amount of biological materials, critical for the “Search of Life” mission goal of NASA. For this project we used a line shape laser beam to excite the targets placed at a distance of 1 meter. The advantage of our directly coupled system is that it provides images which maintain the vertical chemical profile of the target which allows to quickly identifying a biological layer in a layered sample. Figure 1 shows the modified compact remote Raman+LIBS+fluorescence system developed at the University of Hawaii. The University of Hawaii under a NASA PICASSO project is collaborating with NASA LARC to develop an innovative Standoff Ultra-Compact Raman (SUCR) instrument.

![Figure 1: Experimental setup showing target at 1 m distance from the spectroscopy system. All measurements were done with room lights on as shown.](image1)

Methods: In order to measure Raman spectra in daylight from a remote distance without sample collection, it is critical to use a pulsed laser source and a gated detector [1,2]. The working principle of gated remote Raman systems for daytime operation has been described in detail by Misra et al., 2005 [1]. In brief, a short pulsed laser in the order of nanoseconds is used to excite the target. Because the Raman Effect is almost spontaneous, Raman photons are generated in the time frame of the laser pulse. A gated detector is then used to detect the Raman signal within this short nanosecond time frame, lowering the contribution from daylight background and also helping to minimize background phosphorescence signals from luminescent minerals which have longer lifetimes. Hence, a time resolved remote Raman system is capable of measuring highly luminescent minerals in daylight providing good quality Raman spectra and can easily detect fast bio-fluorescence. In a time gated Raman system using pulsed lasers with nano-second pulse width, the biofluorescence is observed as a background along with the Raman signal.

In this study, the laser spot has a line shape. We placed the sample at 1 meter range and adjusted the spot width to ~60 µm, the spot length to ~15 mm (Fig. 1) and the laser power to 5 mJ per pulse. The system uses a simple 1 inch diameter lens to collect the signal from the mineral targets. The data was recorded with all laboratory lights turned on as shown in the photograph. Figure 2 shows a mixed layered sample containing naphthalene, sulfur, potassium perchlorate and Hawaii beach sand. All these materials are of interest to astrobiology community.

![Figure 2: Raw data showing the Raman image obtained from a directly coupled Raman system of a mixed layered sample from 1 m distance with 1 s integration time. The layered sample is composed of Hawaii beach sand on top, potassium perchlorate, sulfur (light yellow layer) and naphthalene (bottom layer) and is shown in the left top and bottom images. The Raman spectral image quickly identifies presence of biogenic/organic materials from signals in the high frequency region (lower spectral trace in right image).](image2)
Results: The right side of Figure 2 shows a raw Raman-fluorescence image of the layered sample. The directly coupled system maintains vertical chemical profile of the target and proper binning shows the Raman detection of four different materials (Fig. 3). Despite some overlapping, Raman peaks are not shifted and materials are easily identified. This information is lost in a fiber coupled system. The images obtained from the directly coupled system can be used to quickly identify a biological layer in a mixed layers target using a line shaped laser beam. This provides means for locating a minute amount of biological material in mineral layers. The high frequency region (2400-4500 cm\(^{-1}\)) shows the detection of organics (C-H stretching vibration of naphthalene) and biogenic fluorescence (fast fluorescence from beach sand). For comparison, standoff Raman spectra along with bio-fluorescence signal of bulk (non-layered) naphthalene, potassium perchlorate, sulfur and Hawaii beach sand are shown in Figure 4. These spectra confirm the detection of biogenic fluorescence and Raman signals due to organics.

Conclusion: A remote Raman imager is demonstrated here to detect mixed minerals and biological materials in a single measurement from a distance of 1 m and 1 s integration time.

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